It is possible that recruitment is so infrequent that planktonically dispersing species cannot maintain populations for long periods of time. This is clearly not a problem for sea urchins of the genus *Strongylocentrotus* (Estes *et al.*, 1989), but for other Aleutian invertebrates successful settlement of pelagic larvae may be a rare event. This kind of recruitment limitation has been proposed as an explanation for fluctuating northern range limits and for heavily adult-biased population structures of invertebrates in northern European seas (Lewis *et al.*, 1982). Until more is known about reproductive patterns and the oceanographical conditions upon which they depend, however, an evaluation of such a hypothesis for the Aleutian fauna is impossible.

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Burrowing Times of *Donax serra* from the South and West Coasts of South Africa

by

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Abstract. Burrowing times of winter acclimated populations of *Donax serra* from the west and south coasts of South Africa were compared at three experimental temperatures in an effort to explain observed zonation patterns. The west coast population burrowed slower than the south coast population at 10°C and 15°C, but at the same rate at 20°C. Burrowing time decreased at increased temperatures. The burrowing rate index ranged from 5 to 14, indicating that *D. serra* is among the most rapidly burrowing bivalves examined to date. The results indicate no physiological adaptation of burrowing rate to temperature between populations.

INTRODUCTION

Members of the bivalve genus *Donax* are common inhabitants of open coastal sandy beaches throughout the warm-temperate and tropical regions of the world (ANSELL, 1983). In response to the dynamic nature of these environments, most species are tidal migrants, burrowing rapidly into the sediments of the beach face between wave swashes. STANLEY (1970) considers members of the genus *Donax* to be among the most rapidly burrowing bivalves.

Of the nine species of *Donax* inhabiting the southern African region (KILBURN & RIPPEY, 1982), *Donax serra* Röding is the best studied (BROWN *et al.,* 1989). Its distribution extends from the Kunene River at the northern border of Namibia into western Transkei, South Africa (Figure 1). Throughout this range, it is capable of maintaining large populations with biomasses of up to 7000–9000 g (dry wt.)/m (MCLACHLAN, 1977; HUTCHINGS *et al.,* 1983). Temperature regimes along the west and south coasts of southern Africa are markedly different, the west coast being dominated by the cold waters of the Benguela upwelling region, while the south coast is influenced by the warm waters of the Agulhas current. Differences in zonation pattern between populations inhabiting the two coasts have also been reported. *Donax serra* is found in low intertidal and shallow subtidal zones along the west coast (HUTCHINGS *et al.,* 1983), while along the south coast it is found in the mid-intertidal zone (MCLACHLAN *et al.,* 1979; DONN *et al.,* 1986).

Members of the genus *Donax* rely on their ability to burrow rapidly in order to maintain their position on highly dynamic beaches (TRUEMAN, 1971). The burrowing mechanisms used by *D. serra* have been described in detail by TRUEMAN & BROWN (1985). MCLACHLAN & YOUNG (1982) have shown that reduced temperatures negatively affect burrowing rate in a south coast population. One would expect a population inhabiting colder waters to have evolved mechanisms to compensate for lower temperatures. Burrowing time is an easily measured parameter relating directly to the bivalve's response to its environment and is important in maintaining zonation patterns. The objective of this study was to compare the burrowing times of south and west coast populations of *D. serra* and to assess any temperature adaptation between the two populations.

MATERIALS AND METHODS

Individuals of *Donax serra* were collected from Maitlands River beach near Port Elizabeth (hereafter referred to as the south coast population) and from Ou Skip north of Cape Town (west coast population) during May–June 1989 (Figure 1). Average expected sea surface temperatures at this time were 17°C for Port Elizabeth and 14°C for Cape Town (CHRISTENSEN, 1980). Annual temperature range for Port Elizabeth is 15–21°C, and 12–15°C at Cape Town (CHRISTENSEN, 1980). Individuals ranged in length from 15 to 75 mm. In the laboratory, bivalves were allowed to burrow into natural Maitlands River beach sediments covered by aerated, flowing seawater and acclimated at 15°C for 36 H prior to initiating the experiment.

Three experimental temperatures, 10, 15 and 20°C, were used, covering the range of temperatures experienced by

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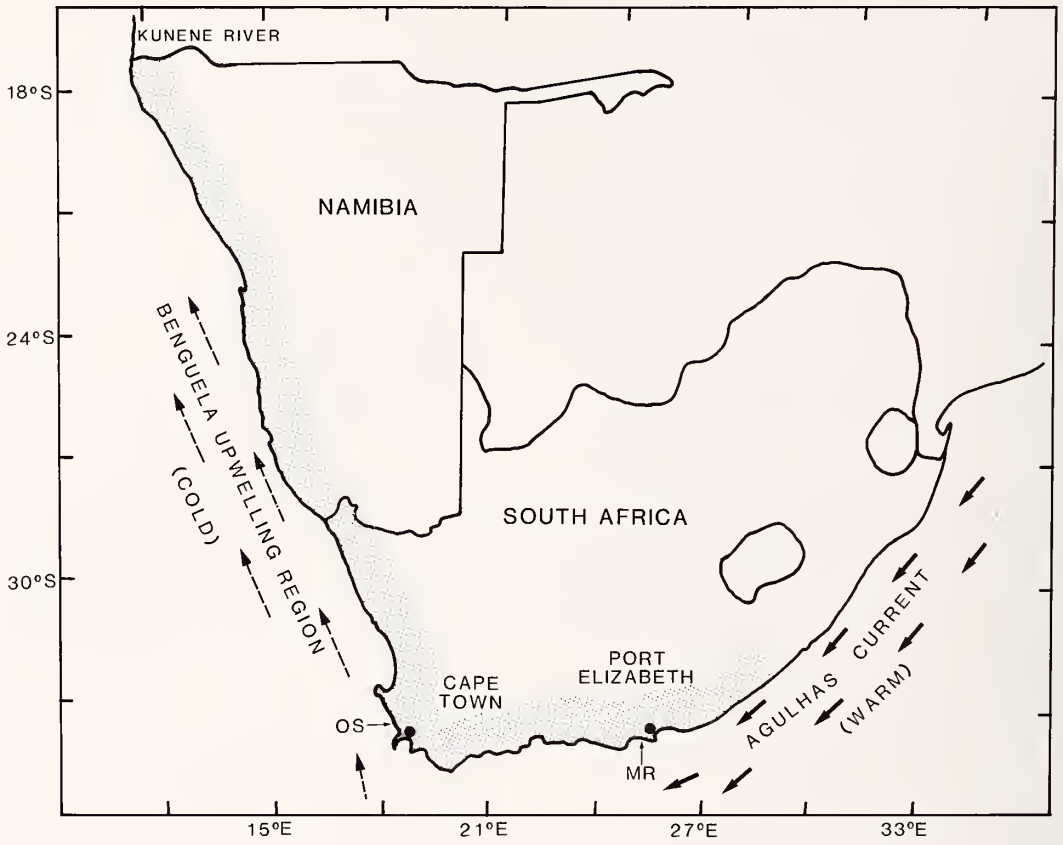

Figure 1

Map of Southern Africa showing distribution of *Donax serra* (shading) and location of sampling sites at Ou Skip (OS) and Maitlands River (MR). Also included are the positions of the Agulhas Current and the Benguela upwelling region.

the species in nature. Animals were transferred directly from the holding tank and placed into experimental chambers. Burrowing time was defined as the time from initiation of digging by the foot until complete burial or until all burrowing activity stopped (McLachlan & Young, 1982). Each animal was allowed to burrow three times and the mean burrowing time determined. At least 30 animals covering the full range of sizes from each site were tested at each temperature.

After having burrowed three times, each individual of *Donax serra* was measured to the nearest 0.1 mm in anterior–posterior length and blotted wet weight determined to 0.01 g. The burrowing rate index (BRI), defined as the cube root of wet weight (g) divided by the burrowing time (s) multiplied by 100 (Stanley, 1970), was calculated.

RESULTS

Most animals burrowed completely. Only a few of the largest west coast individuals of *Donax serra* remained partially ($\leq$10%) exposed when burrowing activity ceased.

Linear regressions of mean burrowing time against length were determined for each population at the three temperatures (Figure 2) and compared between sites using the dummy-variable regression approach (Kleinbaum & Kupper, 1978) (Table 1). Significant differences were detected between the population regression lines at 10 and 15°C, but not at 20°C. Burrowing time decreased with increasing temperatures for the west coast population, *i.e.*, burrowing rate increased. The south coast population showed a decrease in burrowing time between 10 and 15°C, but not between 15 and 20°C.

Analysis of the burrowing rate index (Stanley, 1970) yielded similar results. BRI was independent of *Donax serra* length at all temperatures. A one-way analysis of variance on BRI for *D. serra* at each temperature (Table 2) indicated significant differences between populations. BRI increased with temperature in the west coast population. In the south coast population, BRI increased markedly between 10 and 15°C, but decreased slightly between 15 and 20°C.

DISCUSSION

Stanley (1970) determined the BRI at ambient environmental temperatures for over 60 western Atlantic bivalve